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# Gamma-ray Burst Positions from the ASM on RXTE

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**Abstract.** The RXTE/ASM has detected and positioned 14 confirmed GRB bursts (at this writing, Jan. 1999) including six whose positions were communicated to the community 2 to 32 hours after the burst. Two of these latter bursts led to measurements of optical red shifts but one, despite an easily detected x-ray afterglow, produced no detectable optical or radio afterglow.

**Key words:** gamma-ray bursts – instrumentation

## 1. ASM capabilities

The All-Sky Monitor on RXTE (Levine *et al.* 1996) has the capability to locate Gamma-Ray Bursts (GRBs) to within a few arcminutes in two dimensions. This can occur if the burst falls within the  $\sim 10^\circ$  by  $\sim 50^\circ$  parallelogram on the sky which is viewed simultaneously by the two azimuthal shadow cameras of the ASM (see Levine *et al.* 1996). The solid angle for such detections is actually somewhat larger in some cases because the burst intensity (or that of its immediate afterglow) may remain above ASM threshold as the ASM steps to its next celestial position, *i.e.* to its next “dwell”. This will sometimes bring the burst into the field of view of a camera that had not yet detected it. The ASM takes data for  $\sim 40\%$  of the orbital time.

It is more probable that the burst will fall within the FOV of only one of the three shadow cameras, each with a field of view of  $\sim 10^\circ \times \sim 100^\circ$ . In the case of a detection in only one collimator, the error region will be a few arcminutes wide and a few degrees long.

The RXTE does not carry a dedicated GRB detector, and the ASM detects only the x-ray portion of GRB spectra, 1.5–12 keV. It is therefore difficult to distinguish a rapid x-ray transient from a GRB. Our original method for securely identifying a new transient was to wait until several sightings confirmed the detection. This would distinguish a genuine transient from background events. In the case of GRB, one may have only one sighting. This requires one to impose a higher threshold for detection.

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In addition to “position data” that yields intensities and locations of a source based on 90-s integrations, the ASM records “time-series data” in 1/8 s time bins for each of the three energy channels of each of the three detectors. If a new source is detected in the position data of a given ASM dwell, the presence of rapid variability in the corresponding time-series data improves the likelihood that the source is a GRB.

## 2. ASM burst detections

The RXTE/ASM has detected and positioned 14 GRB since Feb. 1996. Each of the 14 has been confirmed as a burst with detections from GRB detectors on one or more other satellites. Seven of these were detected in two of the ASM shadow cameras, thus yielding positions accurate to a few arcminutes in two dimensions. Of the 14, eight were located in searches of archived data. One of these (GRB 961216) was near the edge of the ASM camera field of view and thus led to a large (and uncertain) error region. The other 7 archival detections and positions are reported in Smith *et al.* (1999) together with detections and positions of these events from other satellites. They are GRB 960416, 960529, 960727, 961002, 961019, 961029, and 961230.

Beginning in August 1997, bursts detected by the ASM were analyzed and positions were reported in near real time. Six events have been so reported at times ranging from 2 to 32 hours after the burst. The error regions reported by us and by others for these six bursts are shown in Figure 1. Notable among these are (1) GRB 970828 (Remillard *et al.* 1997) which had an easily detected x-ray afterglow but no optical or radio signal (Groot *et al.* 1998), (2) GRB980703 (Levine, Morgan & Muno 1998) which led to a radio/optical transient with a redshift  $z = 0.9660$  (Djorgovski *et al.* 1998), and (3) GRB981220 (Smith 1998b) which led to the discovery of a highly variable radio source as a possible counterpart candidate (Galama *et al.* 1998, Frail & Kuulkarni 1998). The radio source was associated with a faint galaxy at  $R = 26.4$  (Bloom *et al.* 1999). The GRB 971214 led to a redshift of

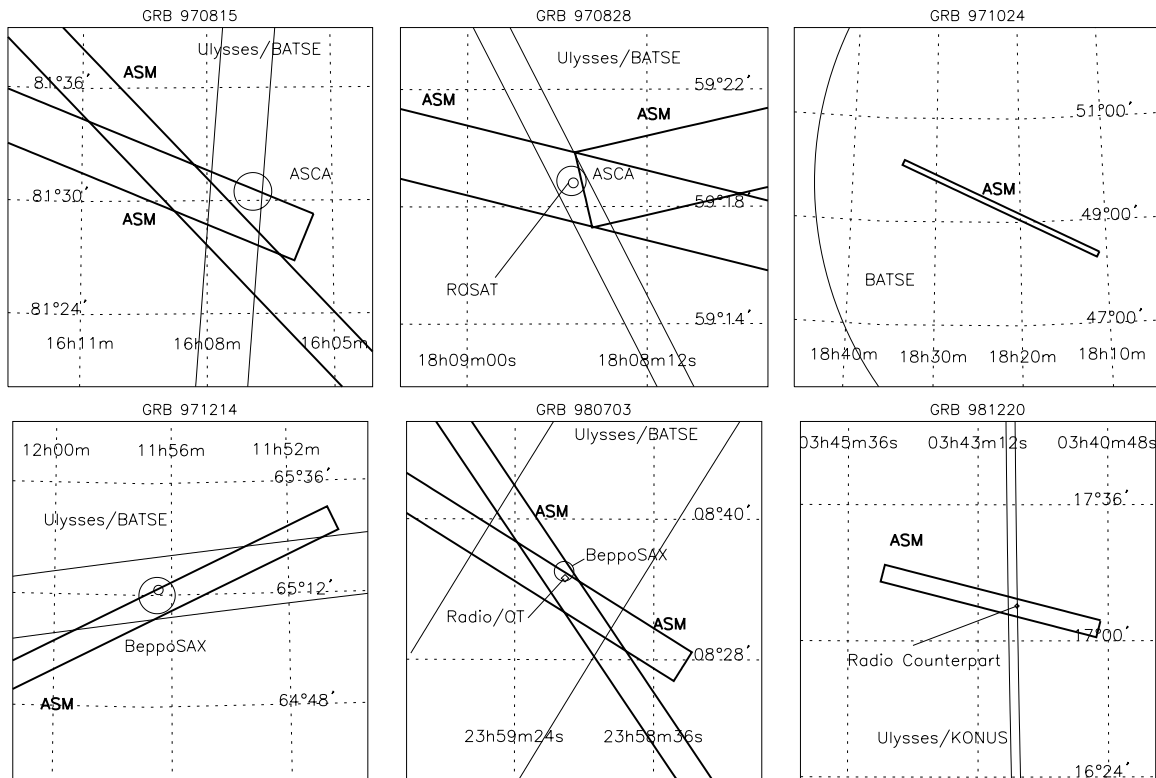


Figure 1. ASM Positions of the six bursts reported in near real time by the ASM group together with refined BATSE and Interplanetary Network positions from other groups as reported or referenced in Smith *et al.* 1999.

$z = 3.42$  but this result came primarily through the precise two-dimensional positions from SAX (Heise *et al.* 1997; Antonelli *et al.* 1997). The ASM results and associated studies are reported or referenced in Smith *et al.* 1999.

### 3. New rapid GRB position GCN alerts

The capability of the ASM system to produce rapid positions of GRB is improving steadily. We have just initiated (Jan. 1999) automatic transmissions to the GCN when the ASM detects a new transient in two different collimators with sufficient signal strength to rule out noise signals with high confidence. These events can be either a GRB or a new transient, and they will have position precision of a few arcminutes in two dimensions. The trigger criteria would have picked up 6 of the 7 two-collimator burst detections recorded since 1996. In addition, it would also have picked up five new x-ray transients in the past year. For example, a preliminary version of this system detected the bright black hole transient XTE J1550–564 at an intensity of only 70 mCrab, very early in its rise from anonymity on 7 Sep 1998 (Smith 1998a). The position notices are now automatically transmitted to the GCN within 5–60 minutes of the burst arrival time under normal operating conditions. We expect that about 1 to 2 GRB events per year will satisfy the trigger criteria.

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